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13. ABSTRACT (Maximum 200 words) <p>The Naval Facilities Engineering Service Center (NFESC), Port Hueneme, California, and Naval Facilities Engineering Command Engineering Field Activity, West, San Bruno, California, took overall leadership in identifying and testing methods to manage waste generated from a machine shop located at Hunters Point Annex, at Naval Station, Treasure Island, California. The machine shop specialized in commercial ship repair operations including corrosion control work. Ship cleaning and equipment maintenance resulted in the accumulation of 4,665 tons of spent sandblasting grit at the site. The spent grit, consisting of silica sand plus a small amount of slag-derived grit, had the physical characteristics of coarse-grained beach sand and also contained fragments of coatings. The spent grit had the potential for exhibiting hazardous characteristics since the coatings included lead-based primers, copper, and butyltin-containing antifouling topcoats.</p> <p>The most beneficial application of reusing the spent grit was to use it as a replacement for some of the fine aggregate in asphaltic concrete. A test program was established that included characterization, bench-scale testing, long-term pilot scale testing, and a full-scale demonstration. Full-scale asphalt production provided samples which proved both the chemical leaching resistance and physical performance characteristics were acceptable. Using spent grit as aggregate is an effective and economically viable option to recycling waste material (U.S. EPA, 1994, and provides waste minimization benefits by avoiding use of landfill space and reducing consumption of resources.</p>				
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## *Recycling Spent Sandblasting Grit and Similar Wastes as Aggregate in Asphaltic Concrete*

### INTRODUCTION

From 1976 to 1986, the U.S. Navy leased most of its Naval Station at Treasure Island, Hunters Point Annex (HPA) to Triple A Machine Shop. Triple A used the facility for commercial ship repair operations including corrosion control work. Ship cleaning and equipment maintenance resulted in the accumulation of 4,665 tons (4,235 tonnes) of spent sandblasting grit at the site. The spent grit, consisting of silica sand plus a small amount of slag-derived grit, had the physical characteristics of coarse-grained beach sand and also contained fragments of coatings. The spent grit had the potential for exhibiting hazardous characteristics since the coatings included lead-based primers, copper, and butyltin-containing antifouling topcoats.

The Naval Facilities Engineering Service Center (NFESC), Port Hueneme, California and Naval Facilities Engineering Command Engineering Field Activity, West, San Bruno, California took overall leadership in identifying and testing methods to manage the waste. Battelle Memorial Institute provided technical support for design and implementation of the testing program. Reed and Graham Asphalt, Inc., prepared the paving for the pilot-scale test and Orland Asphalt, Inc., prepared the paving for the full-scale demonstration.

HPA is located several miles south of San Francisco, California, on the northwestern shore of San Francisco Bay. It is subject to California waste management regulations. The spent grit was not hazardous under the provisions of the Resource Conservation and Recovery Act (RCRA) and the leachable metals tested by the Toxicity Characteristic Leaching Procedure (TCLP) (U.S. EPA SW-846 Method 1311) did not exceed regulatory limits. However, leachable lead and copper exceeded the Soluble Threshold Limit Concentration (STLC) levels for the California Waste Extraction Test (Cal WET)

(California Code of Regulations, Title 22, Section 66262.24(a)(2)(A)). Therefore, under California regulations, the spent grit was considered a hazardous waste.

The spent grit was difficult to treat by conventional cement-based solidification/stabilization methods. The lead and copper contaminants were contained in the organic portion of the paint chips, thereby limiting the ability of inorganic binders to stabilize the lead and copper.

### INNOVATIVE WASTE MANAGEMENT APPROACH

In evaluating alternative ways to use the spent grit, the most favorable method was to use it as a replacement for some of the fine aggregate in asphaltic concrete. Asphaltic concrete uses bitumen as cement mixed with aggregate to form a flexible paving material. The process for preparing hot-mix asphaltic concrete is shown in Figure 1. The organic bitumen binds with the paint chips and immobilizes the metals. In addition, reusing the spent grit as asphalt is a beneficial application of waste material.

The paving material is prepared by combining bitumen with coarse rock and sand mixed in proportion to give it a specified particle size distribution. Typical proportions for the components are 4.5 to 8 percent bitumen, 45 to 60 percent coarse rock, and 35 to 45 percent sand. Due to the high cost of bitumen compared to aggregate, the lowest bitumen content meeting performance specifications is favored.

### RECYCLING TECHNOLOGY

A program was established to demonstrate the implementation and to test the effectiveness of using spent grit as aggregate. The program included characterization, bench-scale testing, long-term pilot-scale testing, and a full-scale



demonstration. Test methods and data quality objectives were determined by the need to demonstrate:

- Reliable immobilization of contaminants to meet Cal WET STLC limits.
- Long-term physical performance equal to conventional fine aggregate.
- No increase in the hazard levels of contaminants in the spent grit for workers or the public.

A bench-scale treatability test using the spent grit as aggregate in asphaltic concrete was conducted in January 1991. The test program included extensive characterization of the chemical composition and physical properties of the spent grit. Asphaltic concrete samples were made with 7 percent grit and a bitumen content ranging from 5.3 to 6.3 percent (based on the total mixture weight). The bench-scale test samples passed California hazardous waste leaching criteria and provided acceptable physical performance properties as defined by local paving specifications. In this case, California Department of Transportation Regulations, Section 39, applied. The bench-scale test also included a study of the fate of butyltin compounds at 325°F (163°C), the high end of temperatures used in asphaltic concrete manufacture.

Success of the bench-scale test provided the basis to design a long-term pilot test (Means et al., 1995). Pilot-scale test strips were laid in November 1991 and initial sample sets were collected. Two long-term performance samples were collected and tested for leaching resistance and physical properties in June 1993 and June 1994.

The pilot-scale test demonstrated that all environmental and physical performance criteria were met. Air monitoring was performed during handling and processing of the spent grit. Potential exposure levels to airborne lead and copper contaminants to workers and the public were more than two orders of magnitude below regulatory limits. Both the initial and follow-up asphalt samples passed the Cal WET chemical tests and physical performance tests.

Old asphalt paving is often removed by breaking or grinding operations that generate high dust concentrations. One set of pilot test strips was removed by conventional road-grinding equipment in July 1993. Air monitoring showed no hazardous contaminants. High airborne dust levels were also measured for the operator of the road grinder. Dust concentrations were high during grinding of the control strip and grinding of the test strips containing recycled grit. High dust levels were not associated with the use of recycled grit.

Ongoing regulatory interaction and coordination was required. The key requirement of the recycling program was to demonstrate that using the spent grit met the conditions of

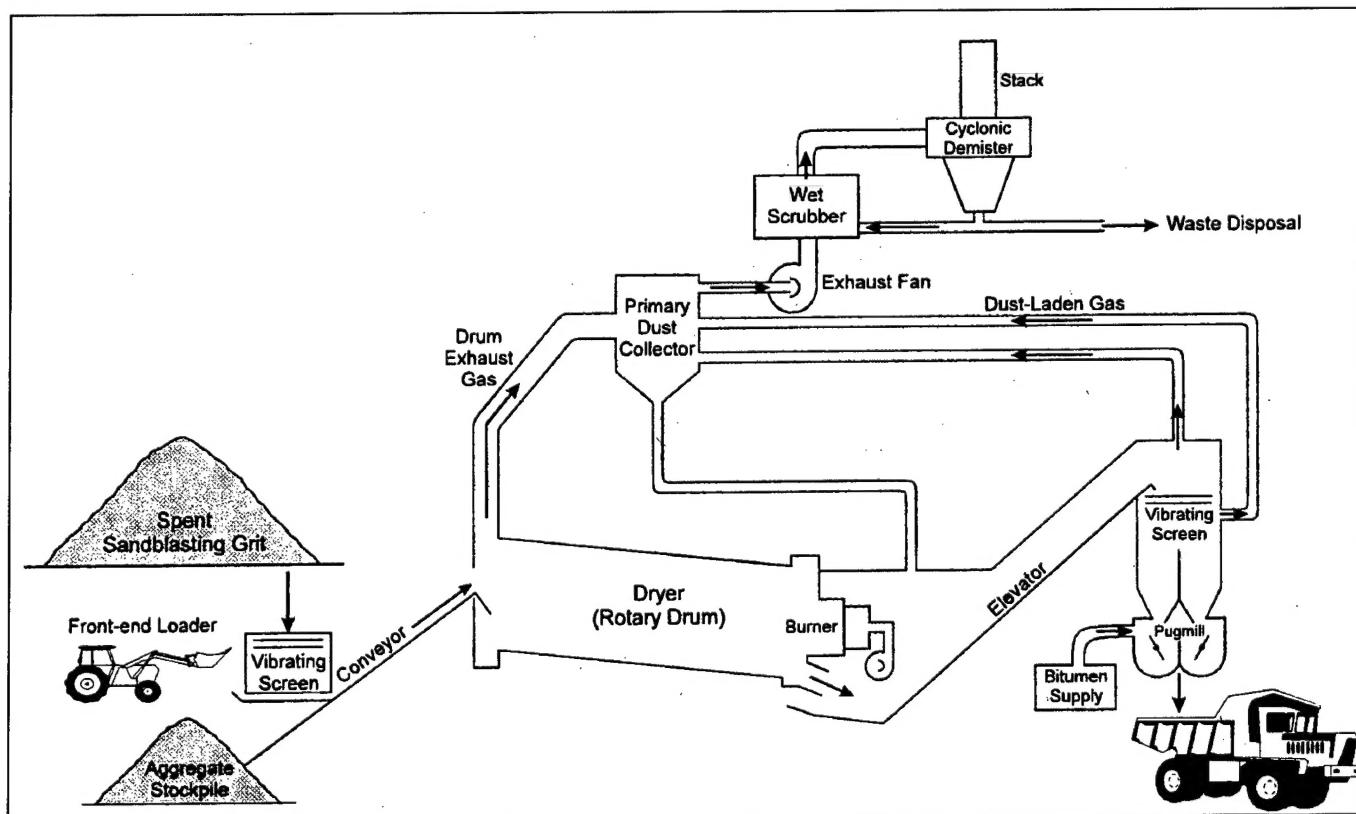


Figure 1. Process schematic of a Hot-Mix Asphalt Plant.

"beneficial reuse" as defined by the California Department of Toxic Substances Control. The results of the long-term pilot test demonstrated that the beneficial reuse requirements could be met. Program reviews and discussions with local air and water quality boards and the local planning commission were also required to obtain a conditional use permit from the Glenn County Planning Department in order for the full-scale demonstration to proceed.

In February 1994, a commercial paving contractor was selected to perform the full-scale demonstration. The contractor designed a mix using spent grit in combination with their bituminous cement and coarse and fine aggregates. The mix design used 5 percent bitumen and 5 percent spent grit, based on the total weight of the mix. The remaining mix contained normal, coarse, and fine aggregate. Bench-scale testing confirmed that the test mix met leachability and physical performance criteria.

Full-scale asphalt production started in June 1994 and continued until October 1995. Samples were taken for every 350 tons (320 tonnes) of recycled spent grit, for a total of 14 samples. Both the chemical leaching resistance and physical performance characteristics of all 14 were acceptable.

#### APPLICATIONS AND COSTS OF RECYCLING TECHNOLOGY

In states where spent grit is not regulated as a hazardous waste, some shipyards have found paving contractors willing to take spent grit for little or no cost. The shipyard must first screen the spent grit to remove debris, perform a TCLP test and sieve size analysis, and transport the screened grit to a

paving plant. Estimated costs for these operations are summarized in Table 1. As a California hazardous waste, the cost to recycle spent grit increases. Additional waste characterization and product quality testing are required and asphalt plants charge fees to cover permits, regulatory interaction, and recordkeeping costs. For example, the paving contractor charged \$40/ton to use the HPA spent grit in the full-scale demonstration. Estimated costs to manage the spent grit as a nonhazardous solid waste, a California waste, and potential savings for recycling are shown in Table 1. It is unlikely that a commercial asphalt contractor would accept a RCRA hazardous waste, without significant regulatory interaction and expense.

#### ADVANTAGES OF RECYCLING WASTES AS ASPHALTIC CONCRETE AGGREGATE

Using spent grit as aggregate is an effective and economically viable option to recycling waste material (U.S. EPA, 1994). This option provides waste minimization benefits by avoiding use of landfill space and reducing consumption of resources. Although the replaced aggregate is not a high-value resource, the average unit price for construction sand and gravel in 1993 was approximately \$3.60/ton/f.o.b. at the mill (Tepordei, 1993). Compared to landfill disposal, using spent grit as aggregate has the potential to reduce waste management costs (see Table 1).

Wastes with physical and chemical properties such as those of sandblasting grit can also be used as aggregate. Candidates as replacements for fine aggregate in asphaltic concrete have the following characteristics:

Table 1. Estimated Costs to Recycle Spent Grit

Operation	Approximate Cost with Non-hazardous Grit (\$/ton)	Approximate Cost with California Hazardous Grit (\$/ton)
Characterization	2.00 to 8.00	5.00 to 11.00
Screening	2.00 to 3.00	4.00 to 6.00
Transportation <sup>(a)</sup>	5.00 to 10.00	10.00 to 20.00
Tipping fee	0.00 to 10.00	40.00 to 60.00
Regulatory compliance	1.00 to 5.00	50.00 to 100.00
Cost to manage by recycling	10.00 to 36.00	109.00 to 197.00
Cost to manage waste	12.00 <sup>(b)</sup> to 70.00 <sup>(c)</sup>	300.00 to 600.00
Estimated savings through recycling	2.00 to 34.00	191.00 to 403.00

Note: (a) Trucking distance 10 to 30 miles  
 (b) South and west central United States  
 (c) Northeast United States

- A high silica content
- Angular particle shape
- About 90% or more of the particles range in size between 0.187-inch and 0.0029-inch (4.75 mm and 0.075 mm)

Soils, slags, and foundry sand containing potentially leachable inorganic contaminants are all possible candidates for recycling as aggregate in asphaltic concrete (Ahmed, 1993; Wisconsin Department of Natural Resources, 1993). Inorganic contaminants can be immobilized by the bitumen cement. Organic contaminants that are compatible with the bitumen can also be incorporated into the paving. Soils contaminated with nonhazardous petroleum product wastes frequently are used in asphaltic concrete (U. S. EPA, 1992).

Certain contaminant and matrix characteristics render some types of waste unsuitable for use as aggregate in asphaltic concrete. Since the paving product using spent grit will be used in close proximity to the public, this recycling option is not suitable for wastes containing highly toxic contaminants such as polychlorinated biphenyls (PCB). Wastes consisting of a high proportion of elemental metal (e.g., steel shot) initially have desirable strength and particle size distribution. However, when the paving is placed into service, the metal slowly oxidizes and expands, causing the paving to crack. Plastic abrasive blasting media are too soft and low in strength to make adequate aggregate for asphaltic concrete.

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## POINTS OF CONTACT

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